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Utilization of On-Line Interactive Displays

by

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SDC

ABSTRACT

The versatility and advantages of using on-line interactiv displays are illustrated by examples from (1) the General Purpose Display System (GPDS), (2) the Pattern Learning Parser (PLP II), and (3) the Bibliographic On-Line Display System (BOLD). Although these systems are designed for different purposes they all utilize displays as communication channels by which the man and the machine are able to engage in a dialog and work together to solve problems. The computer processes data rapidly and displays the results. The information provided in the displays enables the user to steer and control the step-by-step progress of the program. Not only are problems solved more efficiently, but the users are more satisfied by the results achieved.

1. INTRODUCTION

Text processing on a computer is not yet fully automatic. The present state-of-the-art in data and language analysis is such that significant results can best be achieved by a man-machine system in which the computer programs are designed to facilitate on-line interaction by the human decision maker.

Three such interactive programming systems are described in this paper. One is the General Purpose Display System (GPDS), which provides the user with a convenient tool for constructing and manipulating a variety of visual displays. The second is a sentence analysis system (PLP II) that computes and displays the syntactical structure of sentences while the user, viewing the results, makes corrections or selects those analyses that are most satisfactory. The third is an interactive document retrieval system called BOLD which helps the user formulate a search request and displays abstracts of the retrieved documents on the scope so that he can make an immediate decision regarding their relevance.

All three systems operate under time sharing on the AN/FSQ-32 computer at System Development Corporation and use remote stations.

2. EQUIPMENT CONFIGURATION

To enhance flexibility and man-machine interaction, the input equipment provides a functional overlap so that messages can be transmitted by more than one device. The standard inquiry station consists of a teletypewriter and a cathode-ray-tube display console. For GPDS, this equipment is augmented with an auxiliary keyboard, the RAND Graphic Input Tablet, and the control function selection panel. The equipment is arranged as illustrated in Figure 1.

The Teletype

The basic communication device is a standard Model-33 Teletype. This teletype is the only means of communicating with the Time-Sharing System and is also used to load the program into the Q-32 computer.

The Cathode-Ray-Tube (CRT) Display Console and Light Pen

The CRT is the principal output device. It displays both textual and graphic material with a high degree of resolution, and has controls for intensity, focusing, and display positioning. A light pen is attached and may be used as another input device to inform the executive program of the selection of a display option or to identify some portion of a display to be manipulated.

The Auxiliary Keyboard

The auxiliary keyboard has the same key configuration as the teletype and is used in a similar fashion. However, as an input

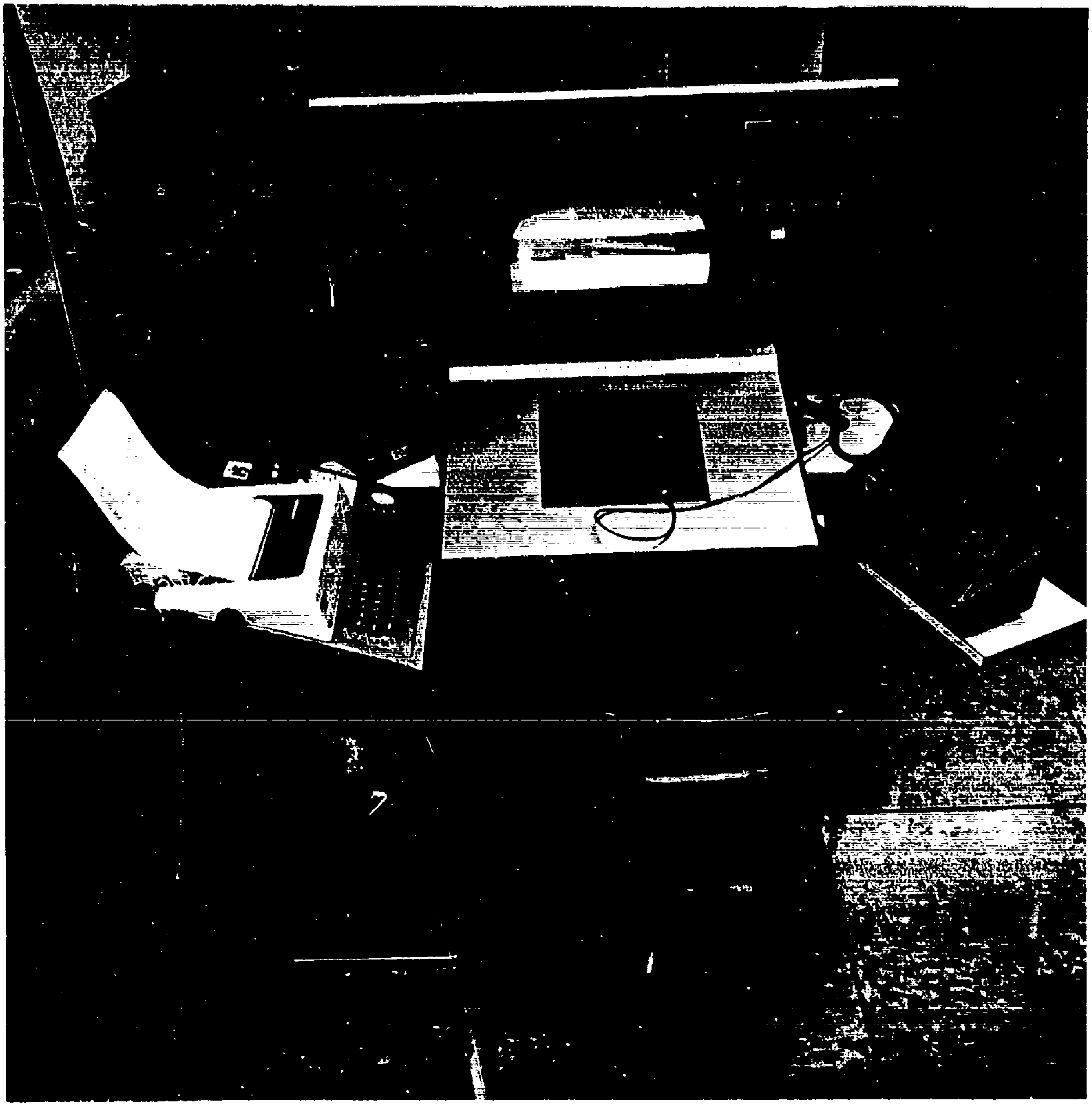

Figure 1. The Augmented User Station (GPDS)

device it is used only with GPDS and it differs from the teletype in two main respects: it produces no printed copy and therefore has no output capability; and it transmits one character at a time to the scope as the keys are depressed, whereas, the teletype transmits a line of characters when the carriage is returned.

The RAND Graphic Input Tablet

The RAND Graphic Input Tablet is an electronic input device consisting of a copper writing surface and a writing stylus. The writing surface is analogous to the display seen at the CRT on a point-by-point basis. Touching the point of the stylus lightly to the writing surface causes the analogous point on the CRT to be illuminated. Pressing the point of the stylus firmly against the writing surface causes the location of the analogous point on the CRT to be transmitted to the computer. The Graphic Input Tablet can be used for the same purposes as the light pen, but it does not have the limitation of being able to respond only to light emitted by the CRT. It is especially useful for producing hand-drawn displays.

The Control Function Selection Panel

The control function selection panel, also called the button box, contains 60 pushbutton switches, of which only 49 are currently being used. When a switch is depressed, an operating command controlling certain aspects of the program is put into operation.

3. GENERAL PURPOSE DISPLAY SYSTEM[1]

Of the three systems that will be described, GPDS is, as the name implies, the most general-purpose display system. It is used for generating and manipulating CRT displays and is designed to be used by persons with varying degrees of sophistication in data processing and computer technology. Built into the system is an extensive explanatory text as well as error-detecting messages. (Vorhaus, 1965; Guillebeaux, 1966). The object is to help the nonprogrammer user, such as a military commander, a business manager, or a scientist, operate the system.

The versatility of this equipment and the GPDS programs can be illustrated through an actual example of usage by the salary administration section at SDC. To insure salary consistency for similarly qualified individuals in different divisions within the company and to insure compatibility of one company's salary schedule with the industry in general, salary statistics are accumulated and placed in a data bank for analysis by GPDS.

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[1]GPDS was developed by SDC in performance of Contract AF 19(628)-5166 with the Electronic Systems Division, Air Force Systems Command, in performance of ARPA Order 773 for the Advanced Research Agency Information Processing Techniques Office, with partial support from SDC's independent research program. The principal investigators are Alfred H. Vorhaus and Sally C. Bowman.

A GPDS process has been written to analyze a subset of a data base, calculate the second order curvilinear regression equations for five specified percentiles (10, 25, 50, 75, and 90), and display the regression curves in graphical format on the scope (Figure 2). This process also has the option of displaying and printing a table of the actual values of the points on the plot as illustrated in Figure 3.

The data so far shown have been for a single company. Similar data exist for the industry as a whole. The analyst working on-line with GPDS may be interested in comparing the salary curves of a single company with the composite for the industry as a whole. He can construct and display the composite salary curve, or build a more complex display in which both the individual company and the composite curves are presented simultaneously.

It is important to note that his particular application of GPDS is being used by salary administration people, who, working with a user's manual and some programming guidance, manipulate a large data bank and construct displays quickly and conveniently to answer a variety of questions.

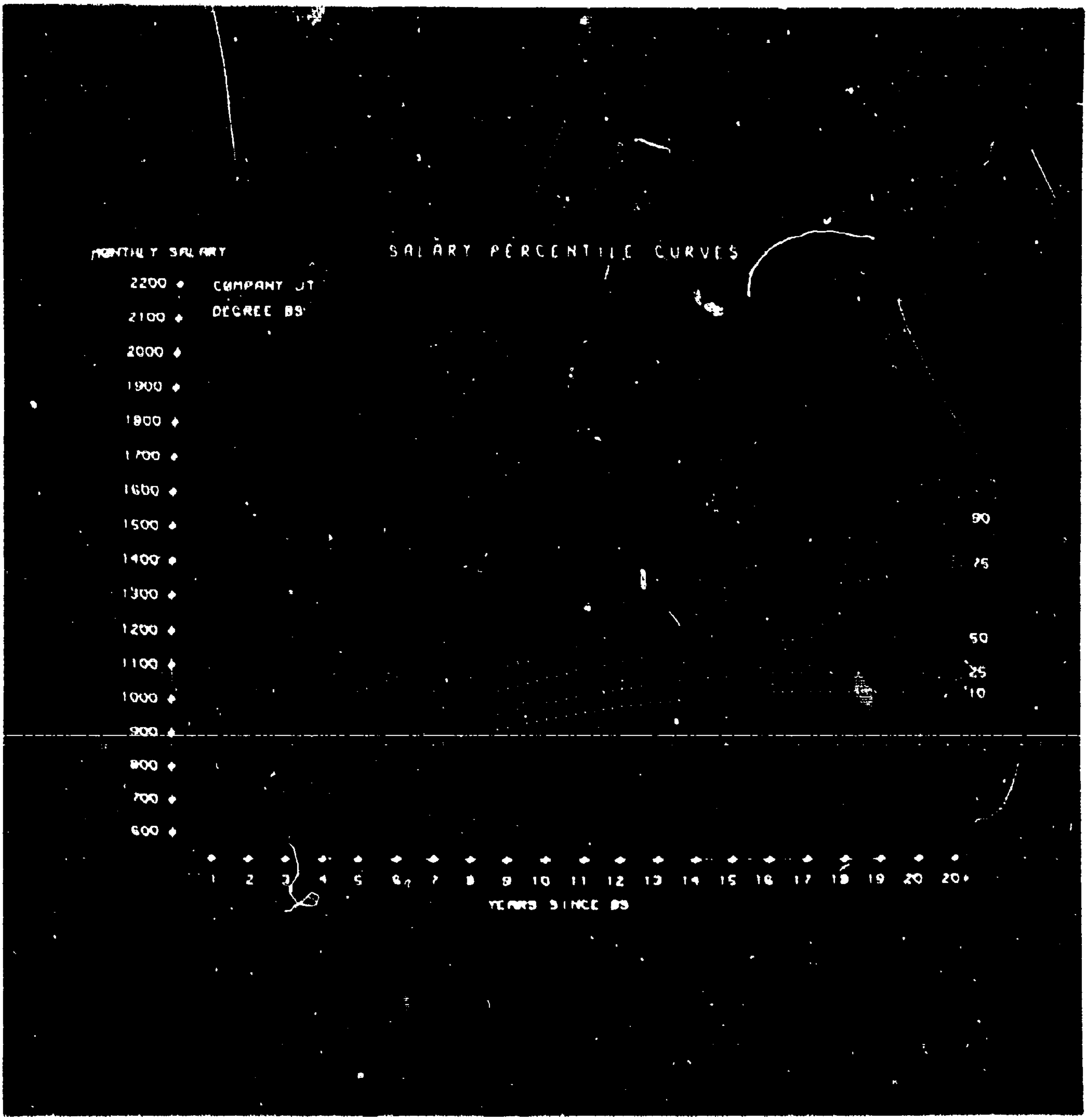

Figure 2. Salary Percentile Curves

COMPANY JT
DEGREE BS

YEARS SINCE BS	10%	25%	50%	75%	90%
1	642	669	686	763	851
2	686	716	742	810	898
3	730	763	795	860	942
4	769	804	842	904	986
5	807	845	889	948	1027
6	839	880	933	989	1069
7	872	916	972	1030	1110
8	901	945	1007	1069	1148
9	925	975	1042	1104	1183
10	948	998	1072	1139	1222
11	969	1022	1099	1172	1254
12	986	1039	1122	1201	1286
13	998	1054	1139	1230	1319
14	1010	1069	1157	1257	1351
15	1019	1077	1169	1283	1377
16	1025	1086	1180	1304	1407
17	1027	1089	1186	1327	1433
18	1027	1089	1189	1345	1457
19	1025	1089	1189	1363	1480
20	1022	1083	1186	1377	1504
20+	1013	1077	1177	1392	1525

Figure 3. Tabular Display of Salary Data

4. SENTENCE ANALYSIS[2]

Information retrieval and automatic question-answering systems require a capability for analyzing statements and questions in natural language. During the past years a number of automatic sentence parsers have been developed but none provide only, nor do they provide all, of the correct analyses. As a result, the Language Processing and Retrieval Staff at SDC has concentrated its efforts on building an interactive system that derives a grammar from manually parsed sentences. The interactive features include the capability for users to change the grammar, to select one of several presented parsings, and to correct errors in the machine parsing.

The system is programmed in LISP 1.5 and operates from an inquiry station consisting of a teletypewriter and a CRT display unit. The program system is called PLP II, since it bears many resemblances to the Pattern Learning Parser previously developed and described by McConlogue and Simmons (1965). This new version, however, contains several unique and interesting features.

[2]This research was sponsored by the Advanced Research Projects Agency Information Processing Techniques Office and was monitored by the Electronic Systems Division, Air Force Systems Command under Contract AF 19(628)-5166 with SDC. The principal investigator is Robert F. Simmons.

(a) First, the input is in the form of sentences that have already been dependency analyzed. From these sentences, the system derives vocabulary and grammar rules that it applies to new sentences of similar structure, the notion being that it is easier to develop a consistent grammar by having the computer derive its own grammar rules from correctly parsed sentences than to develop the grammar manually by making a linguistic analysis of a large corpus of English text.

(b) As a second feature, a dependency analysis and a labelled phrase structure tree are produced and the tree structure displayed for each sentence that the program parses.

(c) In addition to the tree structure, the program produces kernel sentences--one for each sentence string that may be presumed to underlie the surface structure of the sentence (see Chomsky, 1965).

(d) Finally, and most importantly, it is an on-line interactive system. The users have the freedom to change the grammar, to correct the analyses the system makes, and to select from the several parsings the one that is intuitively best suited for his needs.

It is our belief that, for some years to come, such a machine-aided approach will be most effective in obtaining correct analyses of text.

The following example will help explain the operation of the program.

Sentences are input to the system in the following fashion:

THE	OLD	MAN	SAT	ON	THE	BEACH.	Sentence
ART	ADJ	N	V	PREP	ART	N	Parts of Speech
N	N	V	*	*V	N	*PREP	Dependencies

This input is in the form of three strings, where the first is the list of English words in the sentence, the second is the corresponding list of their parts of speech or word classes, and the third is the list showing the word class on which each word in the sentence is dependent. Using the information contained in these three strings, the system augments its existing dictionary with the new vocabulary, word-class items, and dependency rules. A dictionary entry is constructed for each word in the form of a set of 4-tuples containing (1) the word class for the preceding word, (2) the word class of the word itself, (3) the word class of the following word, and (4) the word class on which it is dependent. For the word MAN in the previous example, the dictionary entry would be:

MAN : ADJ-N-V, V

After many such sentences and their analyses have been input to the system and many such dictionary entries have been stored, the system can attempt to parse sentences that have not been analyzed previously. For example, the following sentence was analyzed automatically:

THE BOOK THAT YOU READ IS ON THE TABLE IN THE HALL.

PLP II looks up each word in its dictionary and obtains for each the set of 4-tuple frames that it has thus far accumulated. Generally, this set consists of 3 to 10 such frames for each word. Using the information provided by preceding and following word classes, the system is able to discard most of the frames as being inconsistent with the present context. It is also able to use context clues within the sentence to calculate word classes for words that were not in the dictionary. It does this by predicting, from the word-class contexts of the preceding and following word, the class of the word in question. (A detailed description of the operation of the system is available in Burger, et al., 1966.)

The result of this phase of the program is a dependency analysis of the sentence. By means of a display, the user may examine each string in the analysis and correct any errors. He may also request a display of the phrase-structure tree for the sentence (Figure 4). This tree is automatically constructed from the dependency analysis information with the aid of a brief phrase-structure grammar. As is always the case, additions, deletions, and modifications can be made on-line.

Although the PLP II system is still in an early stage of development, it has proven to be a valuable research tool. It is particularly useful because the researcher can interact with the parsing system in an on-line mode. He can select one of the parsings offered; he can correct errors; he can augment the grammar; and he can modify

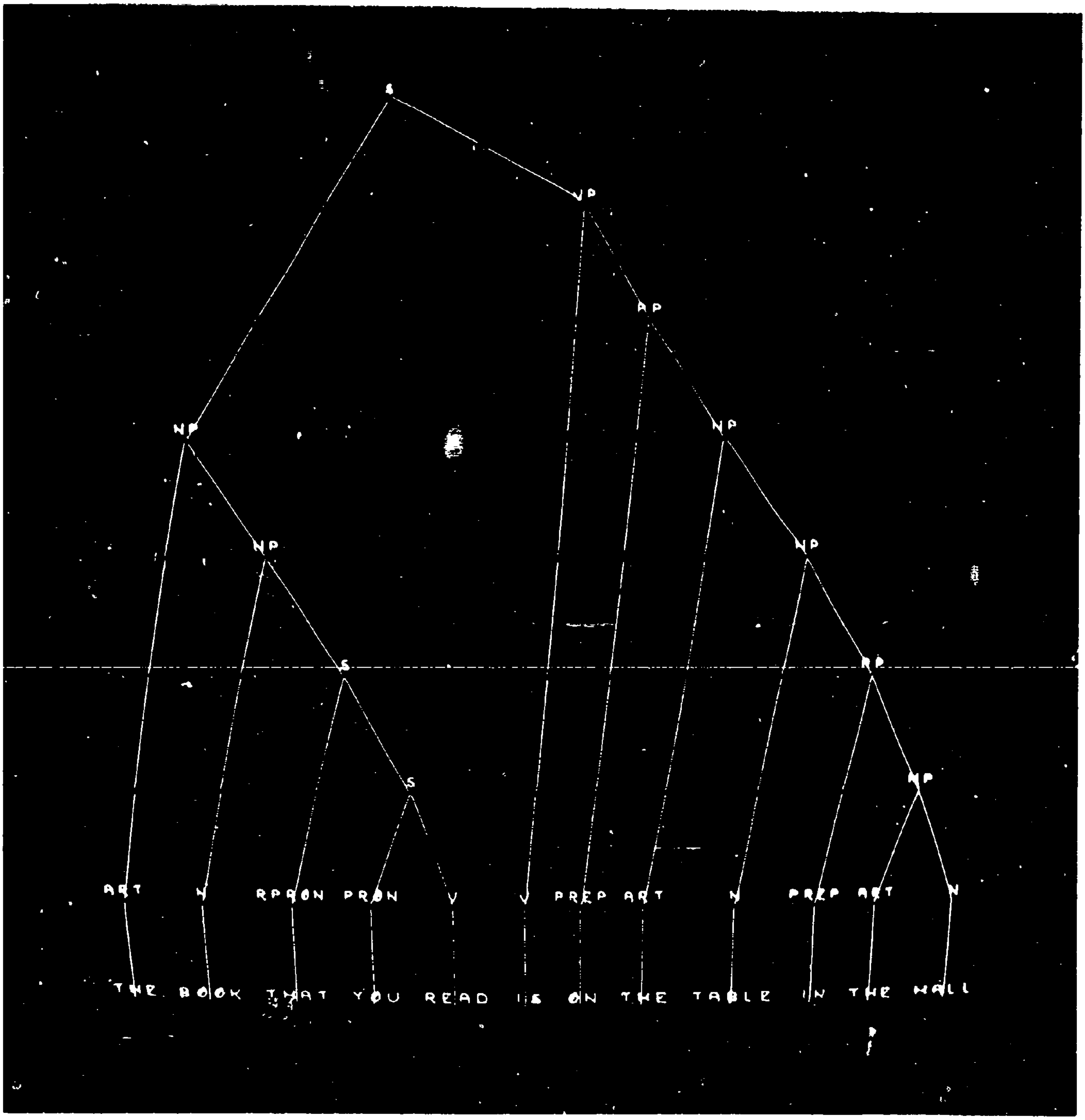

Figure 4. A Phrase Structure Analysis

sentences to gain new insights into the grammar of the language. Furthermore, he can perform all of these operations rapidly, while his interest with the problem is current.

5. BOLD (BIBLIOGRAPHIC ON-LINE DISPLAY)[3]

The third interactive data-base processing program is a document storage and retrieval system called BOLD (Borko and Burnaugh, 1966). The system was designed to allow the user to search for information in a file of magnetically coded and stored document abstracts in much the same manner that he would search through a library. He has the capability of browsing through the collection, examining the documents filed under each subject category, and he is also able to search for documents containing very specific information. If he is not sure of the correct procedures to use, he can receive help and instructions. Most importantly, he is able to state his requests in natural English, for the system would surely fail if the user first had to learn programming before he could retrieve information.

Like GPDS and PLP II, BOLD is programmed for use with SDC's Time-Sharing System. The inquiry station consists of a teletypewriter and display scope with light pen. The programming system has two major modules: (1) the data-base generator program, which builds tables of structured information from a Hollerith prestored magnetic tape, and (2) the display and retrieval program, which retrieves the

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[3]This program is supported by SDC's independent research funds. The principal investigator is Harold Borko.

requested information from the structured data base and displays it on the scope. A technical description of the data base generator and of the display and retrieval subsystems has been prepared by Howard Burnaugh (1966) who wrote the programs.

The data base that is presently being used was obtained from the Defense Documentation Center and consists of abstracts of approximately 6000 documents. For experimental purposes, a subset of these documents is used. The particular tape from which the illustrative examples were derived consists of the first 1745 abstracts and 6883 retrieval terms. The documents are grouped into subject categories organized according to the DDC classification system. However, the program is flexible, and various classification systems and indexing systems can be used.

BOLD is an interactive system, which means that a dialog is established between the user and the system to enable the user to request and obtain relevant documents from the collection. The requests and the system's responses are stated in as close an approximation to natural language as is possible. Ideally, the user with only a knowledge of the English language and a skill in typing should be able to establish a rapport with the machine. Although this ideal may never be fully achieved, a great deal of human engineering skill has gone into the project to approximate it.

After a user has logged in and the data base and program tapes are loaded, the system reports this fact by typing

THIS STATION IS NOW UNDER THE CONTROL OF THE BOLD SYSTEM
OPERATION INSTRUCTIONS R OBTAINED BY THE REQUEST:
INSTRUCTIONS/

Simultaneously, a tutoring display (Figure 5) will appear on the scope. This display defines the ten light-pen actions that are available to the user.

The user begins operation by flashing the "B" character with the light pen or typing BEGIN/ on the teletypewriter. Commands such as BEGIN, SEARCH, BROWSE, CONTINUE, etc., must be followed by a slash. The user types a question mark to ask for help, and for all other interactions no punctuation marks are used.

When the BEGIN command is accepted (signified by //), a new display appears (Figure 6) that indicates the 32 divisions or main subject categories into which the data are divided. If the user wishes a further breakdown, he may use his light pen to flash a division. By doing so, he is requesting more information about that category and receives a display of the subdivisions and the number of entries in the category. If he chooses to browse through the items in this category, he does so by either flashing the □ character with his light pen or typing BROWSE/ on the teletypewriter. He then receives a display consisting of the first abstract in the selected category (see Figure 7). If this abstract is not complete, because of the limited number of characters

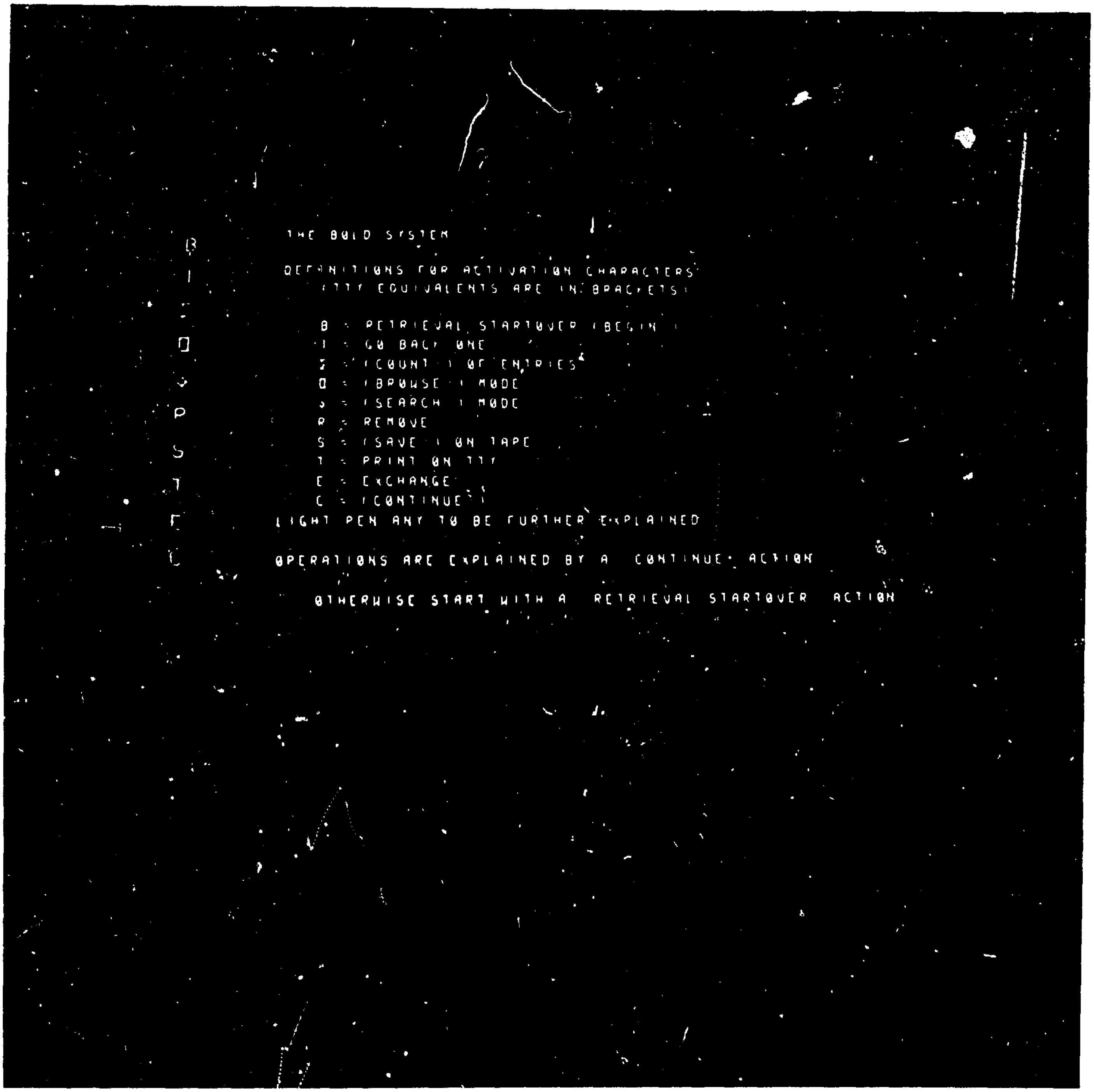

Figure 5. Initial Tutoring Display

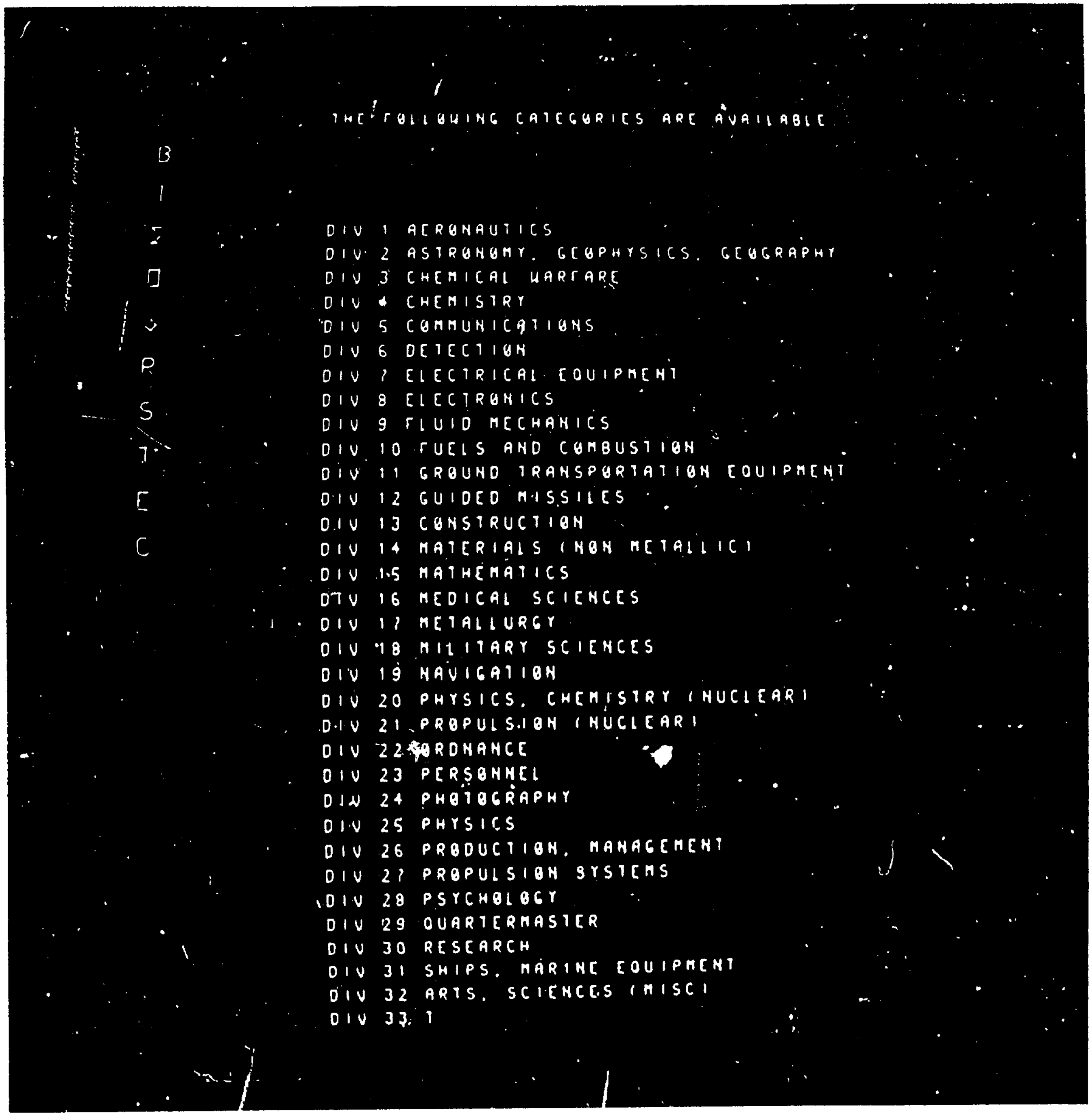

Figure 6. Classification Categories

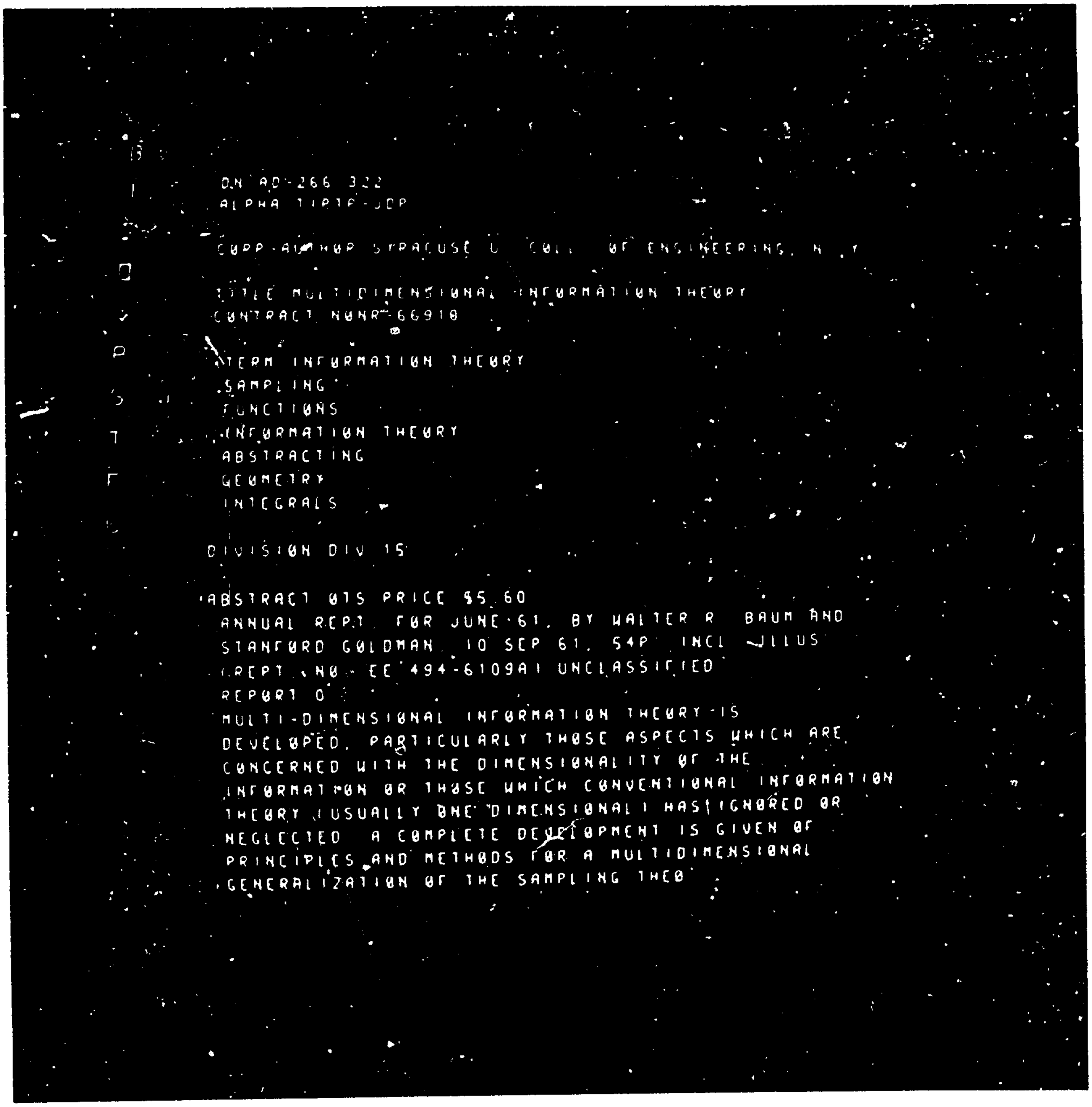

Figure 7. Viewing the Retrieved Abstract

that could be displayed on the scope, he may obtain the remainder by light-penning the "C" or "continue" character. In a similar manner, he can view all the abstracts in the selected category.

Although browsing through an organized collection of documents is one way of searching for information, a more commonly used method is to request documents by subject headings or index terms. Many information centers use a form of coordinate indexing, and retrieve information by combining a number of index terms to form a specific request. Usually a trained information specialist must help the user formulate his request for information into a search request made up of approved index terms. In an interactive system, the user requests help by interrogating the dictionary.

By way of illustration, let us suppose the user is doing research in the field of space travel. He is preparing a report on this subject and he wishes to search the collection for relevant articles. He sits at the inquiry station, and first interrogates the dictionary to determine which words can be used as index terms for retrieval purposes.

The following dialog takes place:

SPACESHIPS?
THESE MAY BE RELATED TO SPACESHIPS
SPACESHIP CABINS
SPACESHIPS
SPACESHIPS - POWER SUPPLIES
SPACESHIPS - STABILITY
*END
SPACE?
THESE MAY BE RELATED TO SPACE
SPACE CAPSULES
SPACE CHARGES
SPACE ENVIRONMENTAL CONDITIONS
SPACE FLIGHT
SPACE FLIGHT - CONTROL
SPACE FLIGHT - SURVIVAL
SPACE MEDICINE
*CONTINUE?YES
SPACE MEDICINE - EFFECTIVENESS
SPACE NAVIGATION
SPACE PERCEPTION
SPACE PROBES
SPACE RECOVERY SYSTEMS, INC., EL SEGUNDO, CALIF.
SPACE SCIENCES LAB., GENERAL ELECTRIC CO., PHILADELPHIA, PA.
SPACE SHIPS
*CONTINUE?NO
LUNAR FLIGHTS?
*NOT FOUND
MOON FLIGHTS?
*NOT FOUND
MARS FLIGHTS?
*NOT FOUND
MOON?
THESE MAY BE RELATED TO MOON
MOON
MOON - ATMOSPHERE
*END
LUNAR?
THESE MAY BE RELATED TO LUNAR
LUNAR PROBES
*END
MARS?
THESE MAY BE RELATED TO MARS
MARS
MARSH CHARLES A.
MARSHALL JOHN M.
*END

He begins by asking whether SPACESHIPS is an index term by typing the word followed by a question mark. The system responds that, in addition to SPACESHIPS, there are a number of other similar terms that are also usable index words. The system finds these related terms by dividing the query word in half and locating all index terms that start with the same combination of letters.

The user, now recognizing that the term SPACESHIPS might be too specific, asks for information about the more general term SPACE. Again the system responds with a set of related terms. Note that the word SPACE by itself is not an index term, for it is always used in combination with another word. In response to a dictionary inquiry, the system types seven index terms and then asks the user whether he wishes it to continue. After two such inquiries, the user feels he has enough information on this subject and tries some other terms. Some of the words he tries are not index terms, but in his interaction he finds enough that are.

As a result of this dialog, and with the information he has obtained, he is now in a position to formulate a search request. He selects six terms and formulates these into a search request by indicating that he would like to have displayed the list of document numbers that contains any one of these six terms; that is, he combines these terms by means of an OR rather than an AND logic, although both the AND and NOT logic are also available.

He makes his requests as follows:

```
SPACESHIPS OR LUNAR PROBES OR MOON OR MARS
     25 ENTRIES ARE REF'D BY          SPACESHIPS
      6 ENTRIES ARE REF'D BY          LUNAR PROBES
     13 ENTRIES ARE REF'D BY          MOON
      3 ENTRIES ARE REF'D BY          MARS
*END
SPACE FLIGHT OR SPACE PROBES
     15 ENTRIES ARE REF'D BY          SPACE FLIGHT
      8 ENTRIES ARE REF'D BY          SPACE PROBES
*END
SEARCH/
     51 ENTRIES
```

Note that when the user types a request, as distinct from interrogating the dictionary, he does not use a question mark. The system tells him how many entries in this data base (1745 abstracts) are referenced by each term.

He now orders the system to

SEARCH/

and the system responds that there are

51 ENTRIES

Since there is a total of 70 documents that have been indexed by these six terms, it is clear that some documents were indexed by more than one.

The system locates these 51 documents and displays the list by identification number and index term. The display appears on the scope (Figure 8). Note that not all the documents can be displayed at one time. Of the 51 entries only 37 have been searched. The user may now remove references to the documents that are of less interest by light-penning "R" and the document number. By light-penning

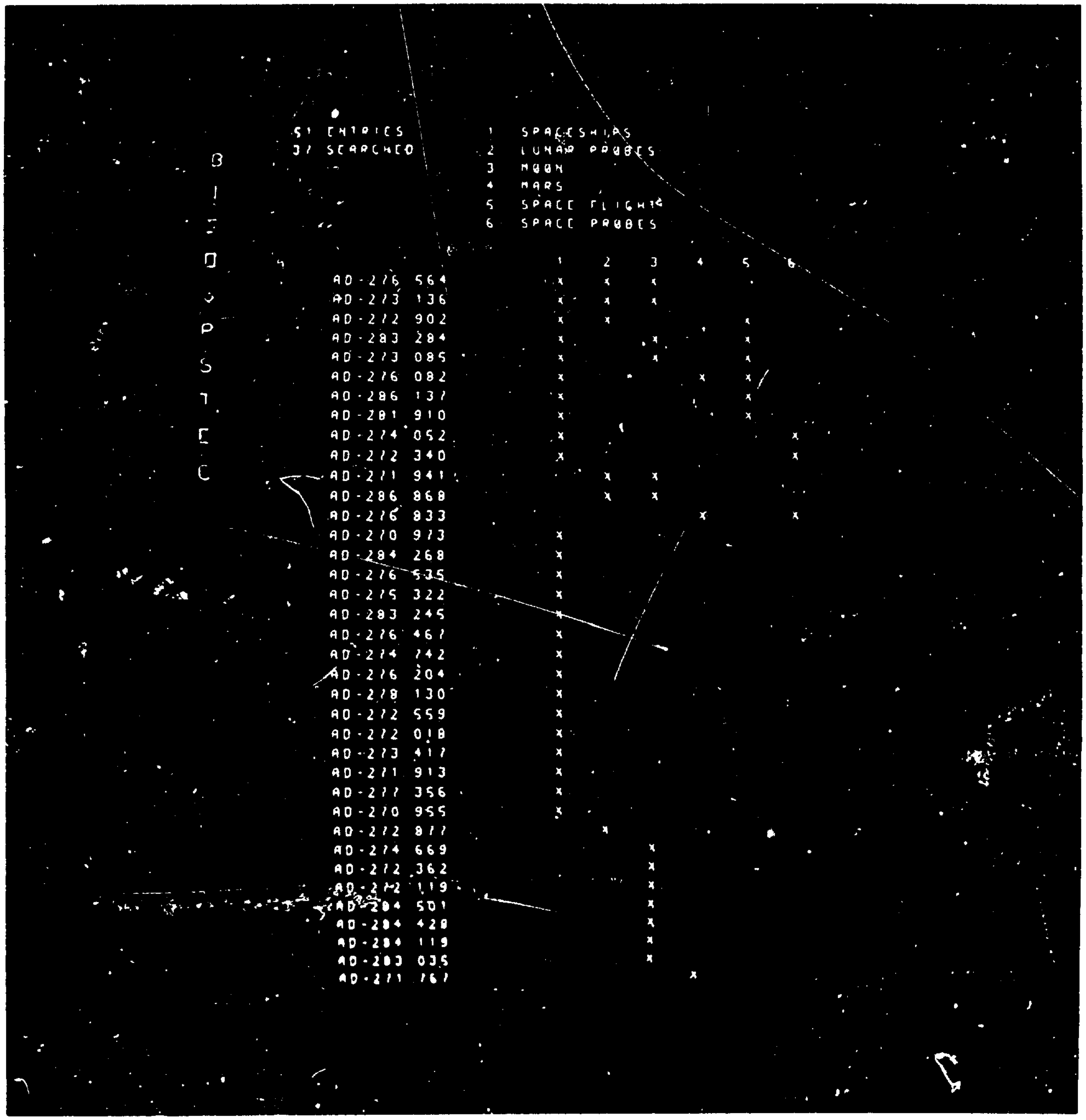

Figure 8. Search Matrix of Retrieved Documents

the "C", or "continue" character, he allows new document references to be displayed. He may also reorder the arrangement of the display by light-penning the "E" character and two document numbers that he wishes to exchange.

Before requesting copies of the 51 documents that have been indexed by one or more of the six retrieval terms, the user would like to have more information about their contents. He may obtain this information by simply typing BROWSE/ or by light-penning the appropriate BROWSE symbol.

The system responds to the BROWSE command with

INPUT ATTRIBUTES WANTED

In this instance, let us assume that the user wishes to see just the author and title of the retrieved articles, so he lists these as the attributes wanted. He could also have requested the index terms, the contract number, the date of publication, or the complete abstract.

The first set of authors and titles is displayed on the scope (Figure 9) and the rest can be obtained by the "continue" action.

Should an immediate permanent record be wanted, it can be obtained by the command

TYPE DISPLAY/

In this manner, the user can browse through the entire set of 51 entries that have been retrieved in response to his request, or that subset of documents that he has not removed from the display. He may save any information that appears for future reference. He interacts with the system, and when he leaves the inquiry station

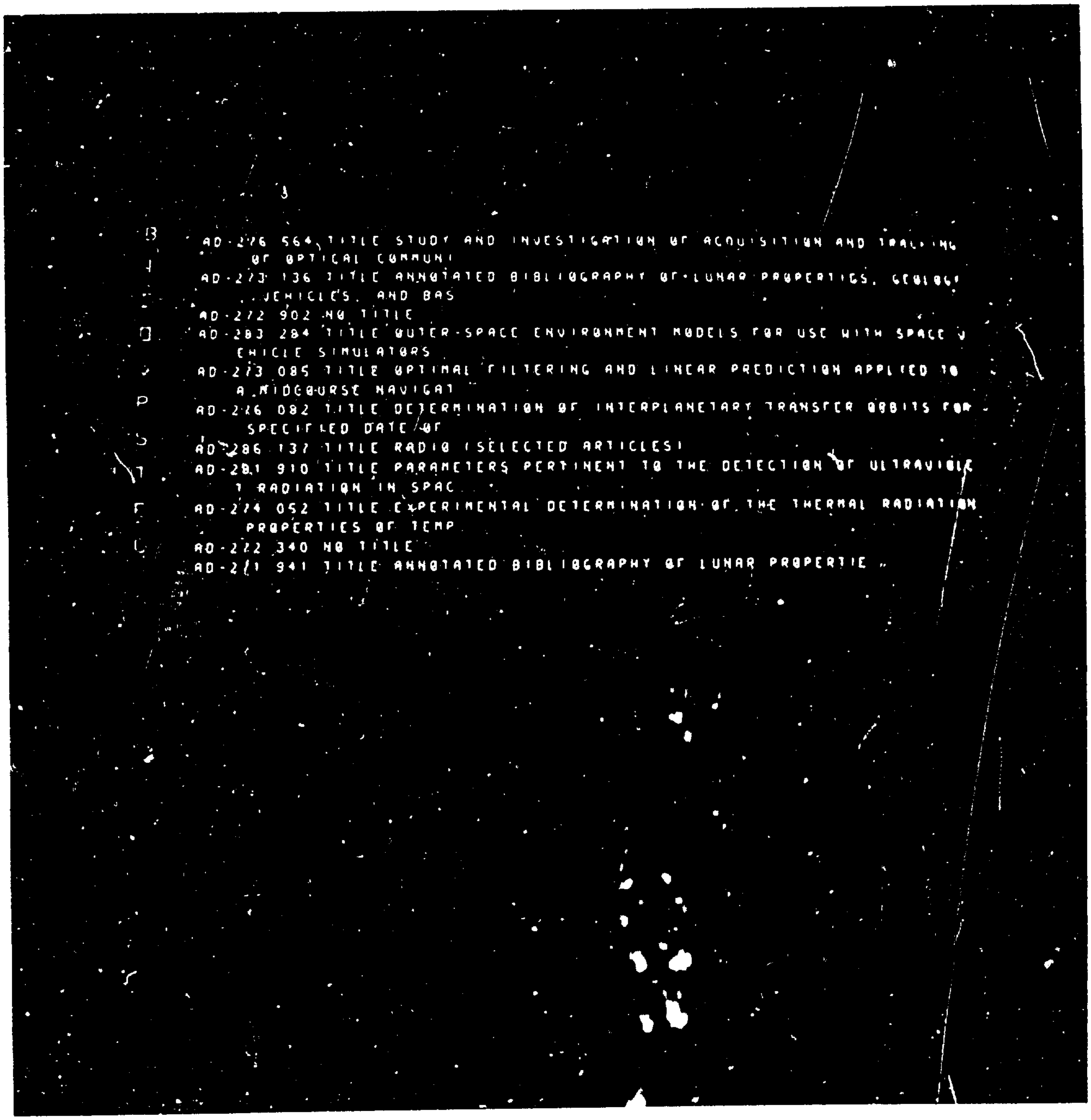

Figure 9. Document Titles and Authors Displayed on Scope (BOLD)

he leaves with the feeling that he has obtained most of the relevant material that the system has in store. The response has been rapid, and the experience has been a satisfying one.

6. CONCLUSION

Three of the SDC interactive programming systems have been described. These are: (1) the General Purpose Display System (GPDS), (2) the Pattern Learning Parser (PLP II), and (3) the Bibliographic On-Line Display System (BOLD). The versatility of these systems is illustrated by the range of problems that they are capable of handling. By using on-line interactive displays, the man and the machine are able to engage in a dialog as both work together to solve problems. The computer processes data rapidly and displays the results. The human decision maker interprets the displays and determines the accuracy and relevance of the results. The information provided in the displays enables him to steer and control the step-by-step progress of the program. As a result of his involvement, problems are solved more efficiently and in a more satisfying manner.

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ILLUSTRATIONS

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Security Classification

DOCUMENT CONTROL DATA - R&D

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Borko, H.

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13. ABSTRACT

The versatility and advantages of using on-line interactive displays are illustrated by examples from (1) the General Purpose Display System (GPDS), (2) the Pattern Learning Parser (PLP II), and (3) the Bibliographic On-Line Display System (BOLD). Although these systems are designed for different purposes they all utilize displays as communication channels by which the man and the machine are able to engage in a dialog and work together to solve problems. The computer processes data rapidly and displays the results. The information provided in the displays enables the user to steer and control the step-by-step progress of the program. Not only are problems solved more efficiently, but the users are more satisfied by the results achieved.

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
On-Line Interactive Displays						
General Purpose Display System (GPDS)						
Pattern Learning Parser (PLP II)						
Bibliographic On-Line Display System (BOLD)						
Man-Machine Communication						

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